POTASSIUM UPTAKE BY COTTON AND CHANGES IN SOIL CHEMICAL PROPERTIES RESULTING FROM THE DEEP PLACEMENT OF DRY FERTILIZER

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Abstract

Field studies were conducted in 1991 on a Norfolk soil (Typic Kandiudults) to evaluate K uptake by cotton as affected by K placement and to determine changes in soil chemical properties resulting from the deep placement of K and agricultural limestone. Potassium uptake was evaluated in an ongoing field test that was established in 1989. Measurements were taken from 5 treatments: 1) no-K check without in-row subsoiling, 2) no-K check with in-row subsoiling, 3) 90 lb K_2O A^{-1} surface applied without in-row subsoiling, 4) 90 lb K_2O A^{-1} surface applied with in-row subsoiling and 5) 90 lb K_2O A^{-1}, deep placed. Changes in soil chemical properties were evaluated in soil treated with 90 lb K_2O A^{-1} or 1500 lb limestone A^{-1}. Potassium uptake and seed cotton yields were higher for the surface broadcast application of K with in-row subsoiling. The deep placement K treatment had a K uptake per plant that was equivalent to the no K in-row subsoiled check treatment. A higher K uptake resulted from the surface broadcast treatment due to the limited soil volume affected by the deep K treatment. Sampling of deep placement treatments showed that when K and limestone were deep placed in the Norfolk soil, the fertilizer was placed in a 2 inch wide band which extended no more than 2.5 inches above the bottom of the subsoil track. Thus, the volume of soil affected was not great enough to result in efficient K uptake which demonstrates that for Alabama soils the deep placement of K for cotton is not justified.

Introduction

In 1989, a series of field tests were initiated in Alabama to evaluate cotton response to deep placement of K and limestone. Interest in this work was generated since many Alabama cotton soils have low pH and low available K in the subsoil. A recent survey of 108 Alabama cotton soils revealed that 81% of the subsoils had medium or lower soil test ratings for K (4). In addition, research conducted in the Mississippi Delta has shown that cotton may respond to in-row, deep placement of K (7,8,9).

The primary purpose of the Alabama studies was to determine the response of seed cotton yield to deep placement of K. Results obtained at two locations for three years and for two years at a third location (5,6) have shown that for Alabama soils deep placement of K is not superior to surface broadcast applications. All three sites had a medium soil test rating for K in the plow layer and a low soil test rating for K in the subsoil.

A secondary objective of these studies was to determine the effect of deep placement of K fertilizer on the growth of the cotton plant. Root density measurements in 1990 and 1991 on a Norfolk soil in central Alabama (6) showed that cotton root density in the in-row position was increased beneath the plow layer by the deep placement of K. Increased root density should improve K uptake since more root surface area should be exposed to accumulate K supplied by diffusion. Seed cotton yield and total dry matter production per plant, however, was highest for the surface K treatments. The observed stimulation in root density should be related to the changes in soil chemical properties that result from the deep placement of K. Potassium uptake by the cotton plant and changes in soil chemical properties resulting from the deep placement of K have not been evaluated.

The objectives of this study were 1) to determine the effect of K placement on K uptake by cotton and 2) to evaluate changes in soil chemical properties resulting from the deep placement of K fertilizer and agricultural limestone.

Materials and Methods

Potassium Uptake

Potassium uptake as affected by the placement of K was evaluated on a Norfolk fine sandy loam located in central Alabama. Soil test K was "medium" for the plow layer and "low" below the plow layer (Table 1). The site has a well developed plow pan at a depth of 6 to 15 inches (6).

The field test was established in 1989 (5,6). Annual treatments consisted of rates of K applied as a surface broadcast with and without in-row subsoiling, or deep placed. In-row subsoiling and the deep placement of K was achieved using a two-row deep fertilizer applicator that was described by Tupper and Pringle (7).

Potassium uptake and seed cotton yields were evaluated on five treatments during the 1991 cropping season. The 5 treatments were: 1) no-K check without in-row subsoiling, 2) no-K check with in-row subsoiling, 3) 90 lb K_2O A^{-1} surface applied without in-row subsoiling, 4) 90 lb K_2O A^{-1} surface applied with in-row subsoiling and 5) 90 lb K_2O A^{-1} deep placed. The experiment had a randomized complete block design with 4 replications. 'Deltapine 50' was the cotton variety.

In 1991, seed cotton yields were determined by mechanically picking the two center rows from each plot. On 27 August, four plants were collected from each plot. Harvested plants were separated into stems, leaves and bolls, dried and weighed. The dried bolls were further separated into burs, seed and lint and weighed. Stems, leaves and burs were ground and 0.5 g subsamples of each plant part were analyzed for K using a dry ash procedure (2). For the seed, 10 seed were weighed and analyzed for K using the same dry ash procedure.

Nutrient Movement

Treatments were applied using the deep fertilizer applicator designed by Tupper and Pringle (7). The treatment area ran parallel to the experimental plots on the Norfolk soil. After treatments were applied the area was kept fallow. The two treatments consisted of the deep placement of 90 lb K_2O A^{-1} or 1500 lb of finely ground dolomitic limestone A^{-1}. The applicator was run at a depth of 15-17 inches. To aid in locating the exact location of the bottom of the subsoil channel, bailing twine was buried as the deep fertilizer treatments were applied. Spools of bailing twine were mounted to the fertilizer applicator and the twine was run down and out the base of the fertilizer delivery tube. Treatments were applied on 25 April 1990.

Approximately 15 months after treatment application (10 July 1991), trenches were dug perpendicular to the direction of the subsoil channels. After locating the buried bailing twine, the face of each trench was smoothed with a spade to be perpendicular with the soil surface. A plexiglass grid was then attached to the face of the trench to aid in collection of soil samples. The grid had 0.5 inch diameter holes which were drilled on 1.25-inch centers. A stainless steel soil probe was used to collect 4-inch soil cores that had a diameter of 0.344 inches. It was assumed that the position of the string represented the bottom and center of the subsoil channel. Soil samples were collected up to 7.5 inches above the bottom of the channel and 5 inches below the bottom of the channel. Samples were also collected to 6.25 inches to the side of the channel. Samples collected at the same position on each side of the subsoil channel were composited. This sampling scheme was used since the deep fertilizer applicator was designed to uniformly distribute the fertilizer in a vertical band at depths of 9 to 15 inches if the applicator is run at a depth of 15 inches. The samples were collected on 24 July. Four trenches were sampled for each treatment. The soil samples were analyzed for pH and Mehlich I (3) extractable Ca and K.

Results and Discussion

The surface application of K in combination with in-row subsoiling resulted in higher plant uptake of K as compared to the other treatments (Table 2). There were no differences among the remaining treatments for K uptake. Thus, K uptake by cotton plants grown on the deep placement treatment was no different as compared to plants grown on the no K check treatment that was in-row subsoiled. Higher K uptake was observed for the surface application of K with in-row subsoiling even though Mullins et al. (6) observed a stimulation in root growth beneath the plow layer for the deep K treatment. Mullins et al. (6) speculated that a higher proportion of the root system was exposed to the applied K in the surface K treatment. In 1991, the highest seed cotton yield was obtained from the surface application of K in combination with in-row subsoiling.

Soil pH as affected by the deep placement of 1500 lb limestone A^{-1} is shown in Fig. 1. The data in Fig. 1 show that at the bottom of the subsoil channel a pH of $\simeq$ 7.5 was obtained within 1.25 inches to either side of the center of the channel. Soil pH decreased sharply to $\simeq$5.2 between 1.25 and 2.5 inches to the side of the channel. During the excavation of the fertilizer treatments a 2-inch wide band of unreacted limestone was found at the bottom of the subsoil channel. The data in Fig. 1 also show that there was very little change in pH below the bottom of the subsoil channel. Directly below the base of the channel, within 1.25 inches to either side of the channel, there was an increase in pH of approximately 0.5 unit. At 2.5 inches below the channel there were no changes in pH. Likewise, at 1.25 inches directly above the bottom of the channel there was an increase in pH of approximately 1 unit. However, there were no changes in pH and a distance of $\geq$ 2.5 inches above the bottom of the channel.

Mehlich I (3) extractable Ca paralleled the pH data (Fig. 2). There was a tremendous increase in extractable Ca at the bottom of the channel and within 1.25 inches to either side of the channel center. There was little if any effect of the deep placement of limestone at distances > 1.25 inches below or above the bottom of the channel. The data in Fig. 2 shows conclusively that most of the deep placed lime fell into a 2 inch wide band at the bottom of the subsoil channel. Thus, essentially all of the limestone was deposited in a volume of soil that extended no more than 2 inches above the base of the subsoil channel.

Soil test data collected from treatments receiving 90 lb K_2O A^{-1} are summarized in Fig. 3. As with the limestone treatment, the greatest change occurred at the bottom of the subsoil channel. The data in Fig. 3 show that there was essentially no influence of the deep placement of K on soil test K at a distance $\geq$ 2.5 inches above the bottom of the channel. There was some lateral and downward movement of the K applied as soluble muriate of potash. Downward movement of the applied K was observed up to five inches below the bottom of the subsoil channel. Likewise, the applied K moved laterally as much as five inches away from the point of placement. Mullins et al. (6) reported that subsoiling of the Norfolk soil disrupted the well developed traffic pan up to 10 inches away from the in-row position. Thus increased water infiltration within the subsoil channel could account for the lateral movement of the applied K.

Summary

Measurement of K uptake on a soil with a well developed plow pan showed that surface broadcast applications of K with in-row subsoiling resulted in a greater uptake of K as compared to in-row deep placed K. Likewise higher seed cotton yields were obtained from the surface application of K with in-row subsoiling. Higher K uptake resulted from the surface broadcast treatment because of the limited soil volume affected by the deep K treatment. When K and limestone were deep placed in the Norfolk soil, the fertilizer was concentrated in a 2 inch wide band which extended no more than 2.5 inches above the bottom of the subsoil track. In conclusion, the results obtained from this site in combination with the results obtained from two other sites in Alabama (5) show conclusively that for Alabama soils the deep placement of K for cotton is not justified.

References

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Table 1. Initial chemical properties of the Norfolk soil

Depth	CEC	pH	Mehlich I Extractable P	K	Mg	Ca
-inches-	meq/100 g		---------- lbs/acre		-------	
0 to 6	4.77	7.0	92(H)[1]	91(M)	168(H)	730
6 to 12	4.84	6.2	84(H)	68(L)	78(H)	580
12 to 18	4.96	5.6	17(L)	84(L)	91(H)	550

[1] Soil test ratings by Cope et al. (2). VH = 'Very High'; H = 'High'; M = 'Medium'; L = 'Low'.

Table 2. Effect of subsoiling and deep placement of K fertilizer on seed cotton yields and K uptake.

Treatment	Cotton Yield 1991	Potassium Uptake
	-- lb/A --	-g/plant-
Check - SS	2589a[1]	1.21b[1]
Check + SS	2859ab	1.47b
90 lb K20 - SS	3079ab	1.36b
90 lb K20 + SS	3292b	2.48a
90 lb K20 Deep	2932ab	1.76b

[1] Means followed by different letters are significantly different at the 0.10 level of probability.

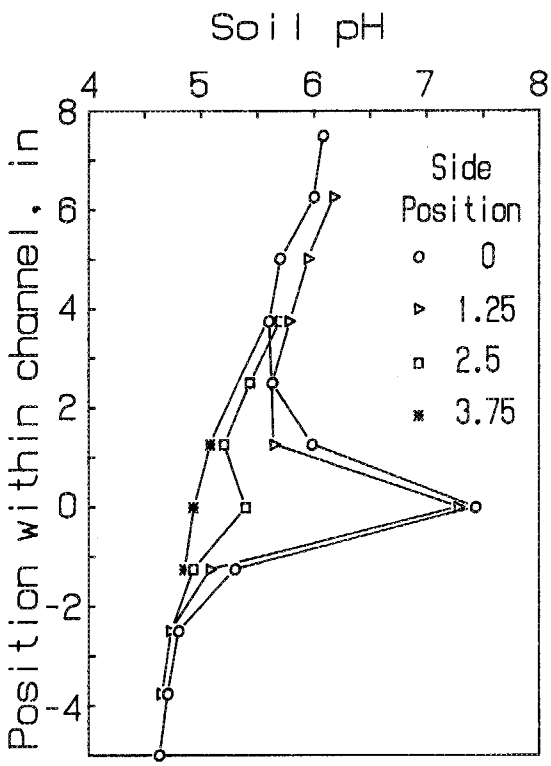

Figure 1. Changes in soil pH above and below the bottom of the subsoil track as affected by the deep placement of 1500 lb A^{-1} limestone. Side position refers to the distance (inches) to the side of the subsoil track center.

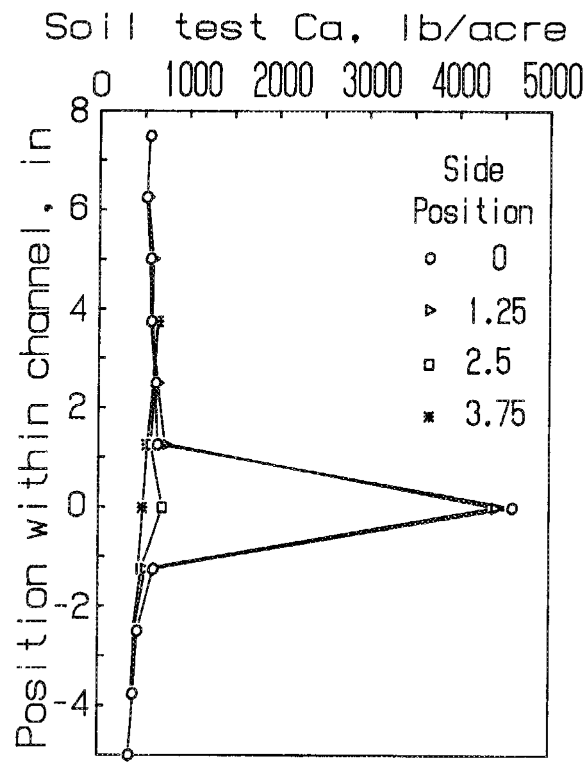

Figure 2. Changes in soil test Ca above and below the bottom of the subsoil track as affected by the deep placement of 1500 lb A^{-1} limestone. Side position refers to the distance (inches) to the side of the subsoil track center.

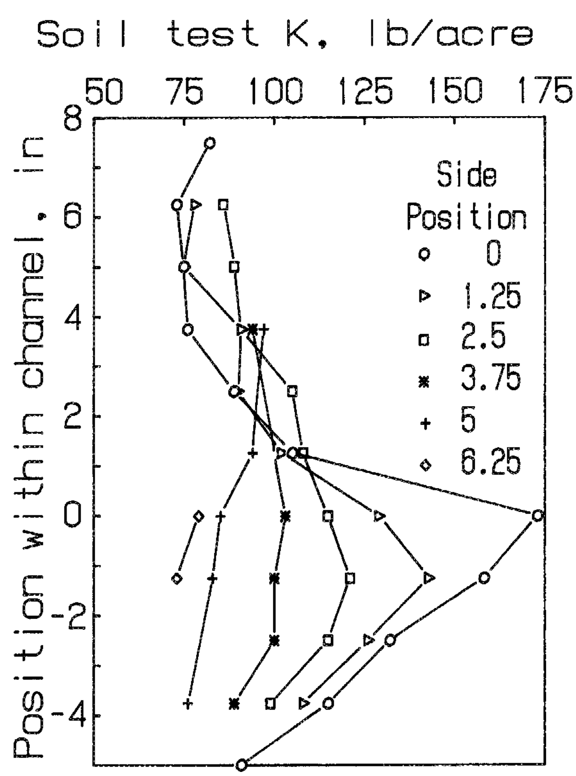

Figure 3. Changes in soil test K above and below the bottom of the subsoil track as affected by the deep placement of 90 lb K_2O A^{-1}. Side position refers to the distance (inches) to the side of the subsoil track center.